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Wind turbine manufacturing industry in China: Current situation and problems

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ABSTRACT

With fast development of the global wind energy market in recent years, China is attaching greater importance to developing the wind power industry and increasing the proportion of wind energy. Currently, the cumulative installed capacity of wind turbines in China is listed among the top ranks in the world. Manufacturing industry is the key to development of wind energy. Although there is a relatively complete manufacturing and supply chain for wind turbines in China, including infrastructures for manufacture of almost all major parts, the design technology and key components of wind turbines still rely on imports. Therefore, problems still exist in the development of wind power industry. However, few papers focus on this aspect at present. In this paper, the current development of wind power industry in China is investigated, and exiting problems are discussed. The aim of this paper is to let more experts know the situation and do something for the wind power industry in China.

Contents

1. Introduction

With vast land and a long coastal line, China has very rich wind resources. As studies show [1], there is enormous potential wind

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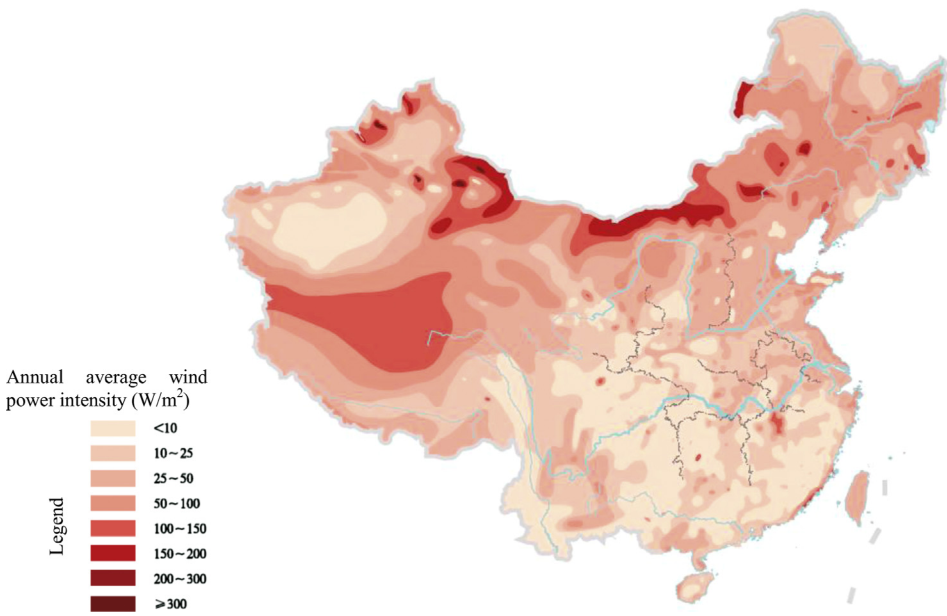


Fig. 1. Distribution of average wind power intensity at 10 m above the ground on land of China.
Source: The Third National Wind Energy Resources Census [1].

power available in China. According to the Third National Wind Energy Resources Census, wind power could be developed over a land area of about 200,000 km^2 in China with the wind power intensity at 150 W/m^2 or greater, as shown in Fig. 1. The solid resource foundation will surely support wind power to become a significant part of the future energy structure in China.

Since the first wind turbine was connected to the grid in 1985, the wind power industry has experienced progress from slow growth to rapid development; the corresponding wind power market has been gradually established. In the wind turbine market, the manufacturing industry is confronted with intense competition but is also becoming mature; there are more large energy enterprises becoming developers; and the pricing policy for wind energy is becoming stable. In brief, the wind energy market in China is developing into a positive cycle [2].

In China, the installed capacity of wind turbines has been growing fast, and its industrial concentration has further intensified. At present, the domestic wind turbine manufacturers have occupied over 90% of the supply market in China, and are beginning to export products [3]. The wind turbine manufacturing industry clearly features three rankings: Goldwind, Sinovel, United Power and Mingyang among the world's top ten suppliers [4] in the first ranking; Dongfang Turbine, Shanghai Electric, Envision Energy and XEMC in the second; a range of smaller manufactures in the third. Driven by the international wind power development trend, larger wind turbine manufacturers in China have begun to engage themselves in competition of large-scale wind power equipment. Sinovel, Goldwind, XEMC, Shanghai Electric Group and Mingyang are all developing wind turbines with the power of 5 MW or larger and are expected to develop competitive and technically mature equipment. However, the major concern in this industry is the quality of products. Generally, the domestic wind turbine industry in China confronted a great test in 2011 and 2012; it had successfully undergone the test and realized leap-forward development. Though there is a relatively complete manufacturing and supply chain for wind turbines in China, including infrastructures for manufacturing almost all major components, some key components still rely on imports, while a perfect auxiliary service system, including certification organizations and basic development & research, is still absent [3]. This paper is to review the current situation of the wind turbine manufacturing industry in China, and analyze the problems in its current development.

Table 1
Top 20 wind turbine manufacturers in China for newly increased installed capacity in 2012 and their market shares.
Source: Statistics on Wind Turbine Installed Capacity in China in 2012, by Chinese Wind Energy Association under Chinese Renewable Energy Society [6].

Manufacturer	Installed capacity (MW)	Market share (%)	Manufacturer	Installed capacity (MW)	Market share (%)
Goldwind	2521.5	19.46	Haizhuang Windpower	399.5	3.08
United Power	2029	15.66	Zhuzhou Times Electric	385.8	2.98
Sinove	1203	9.28	WINDEY	364.5	2.81
Mingyang	1133.5	8.75	SANY	275	2.12
XEMC	893	6.89	CCWE	263.1	2.03
Shanghai Electric	822	6.34	XJ Windpower	172	1.33
Envision Energy	544	4.20	HEAG	114	0.88
Gamesa	493.2	3.81	Shenyang TEWIN	78	0.60
Dongfang Turbine	466.5	3.60	GE	60	0.46
Vestas	414.4	3.20	INHE Windpower	57.5	0.44
Else	270.5	2.09	Total	12960	100

2. Current situation of the equipment manufacturing industry

2.1. Self-independent brand construction

Before 2000, wind turbines of domestic brands were virtually unknown in China's domestic market. Since 2003 the country had organized five successive invitations to bid for national wind power concessions, allocating the right to construct wind power

Table 2
Research and manufacture of offshore wind turbines in China.
Source: China Wind Power Report 2012, China Environmental Science Press [3].

Manufacturer	Research, development and products
Sinovel	3 MW batch installation; 5 MW, 6 MW prototypes
Goldwind	3 MW prototype; 6 MW under research
Dongfang turbine	3 MW, 5.5 MW under research
United power	3 MW, 6 MW prototypes
Mingyang	3 MW prototype; 6 MW under research
XEMC	5 MW prototype
Shanghai electric	3.6 MW prototype; 6 MW under research
Haizhuang	5 MW prototype
SANY	6 MW under research
CCWE	3 MW prototype
Zhuzhou times electric	2.5 MW prototype; 5 MW under research
WINDEY	2.5 MW prototype; 5 MW under research
HEAG	3 MW prototype; 5 MW under research
Envision energy	6 MW under research

Table 3
Exports of wind turbines from China in2012.
Source: Statistics on Wind Turbine Installed Capacity in China in 2012, by Chinese Wind Energy Association under Chinese Renewable Energy Society [6].

No.	Manufacturer	Qty.	Capacity (MW)	Exported to
1	Sinovel	36	54	Turkey
		22	52.5	Italy
		12	36	Spain
		23	34.5	Brazil
2	Goldwind	26	43	U.S.A
		13	19.5	Australia
		11	16.6	Ecuador
		3	7.5	Thailand
		1	0.75	Uzbekistan
3	HEAG	17	61.2	U.S.A
4	SANY	25	50	U.S.A
5	Mingyang	33	49.5	Bulgaria
6	XEMC	2	4	Iran
7	WINDEY	1	1.5	Iran
Total		225	430.45	

projects with the installed capacity of more than 3 GW. In 2005, planning of GW-scale wind power bases was commenced; in 2008, 10 GW-scale wind power bases were planned and constructed [5]. All these had strongly pushed forward development of the wind turbine industry in China, created sound market conditions for wind turbine manufacturers, stimulated fast development of the wind turbine manufacturing industry and advanced the formation of self-independent brands. Before 2005, there was only one Chinese wind turbine manufacturer listed among the top 10 in the world [5]; in 2012, four were listed as the world top 2, 7, 8 and 10, respectively [3]. Sinovel, Goldwind, Mingyang and United Power were regarded as world-renowned wind turbine brands. The wind turbine manufacturing industry in China was becoming even mature. In 2012, among the top 20 wind turbine manufacturers, there were 17 domestic manufacturers and 3 international manufacturers. The 17 domestic manufacturers shared 90.45% of the newly increased installed capacity, while the 3 international manufacturers shared 7.47%, as shown in Table 1.

2.2. Technological level of the equipment

Before 2005, the newly installed MW-scale wind turbines on wind farms in China accounted for a small proportion in the newly installed capacity of the year. With the increased production of MW-scale wind turbines by domestic companies, the installed capacity of MW-scale wind turbines increased to occupy 51% of the newly increased market in 2007, 72.8% in 2008 and 86.8% in 2009 [5]. MW-scale wind turbines became the mainstream products in the Chinese wind turbine market. To follow the global trend of large-scale wind turbines, many domestic manufacturers also started to research and develop MW-scale equipments.

Since 2010, new achievements have been made in research and manufacture of MW-scale wind turbines (no less than 2 MW). For example, the 3MW wind turbine researched and manufactured by Goldwind Science & Technology Co. Ltd. was put into trial operation; the 3 MW offshore wind turbine researched and manufactured by Sinovel Wind Power Co. Ltd. was connected to the grid on the offshore wind farm at the Donghai Bridge; and the 3 MW wind turbine researched and manufactured by Shenyang University of Technology successfully came off line. In addition, Sinovel, Goldwind, Dongfang Turbine, Haizhuang and XEMC have started to research wind turbine with the capacity of 6 MW [3]. Research and development of multi-MW-scale wind turbine has also been commenced in China.

In particular, to satisfy the needs of the international and domestic offshore wind power markets, the domestic manufacturers in China have also begun to research and develop or even tried to manufacture offshore wind turbine, having achieved positive progress. For details of research, development, trial production by the domestic manufacturers, see Table 2.

2.3. Export of complete equipment

In 2012, China attempted to export complete wind turbines, and had exported 225 sets to 11 countries, totaling 430.45 MW. The major exporters were Sinovel, Goldwind, HEAG, SANY, Mingyang, XEMC and WINDEY etc., as shown in Table 3.

2.4. Development of the manufacturing industry

According to the preliminary statistics [6], by late December 2012, there had been 28 manufacturers engaged in manufacturing large-scale complete equipment, in which some domestic wind turbine manufacturers introduced technologies from overseas either through production license or by joint design, while some other manufacturers industrialized domestic technological achievements and carried out independent research and development of complete equipment technologies. Based on the manufacturing capacity and equipment conditions, these manufacturers were classified into the following five groups.

Group 1: wind turbine manufacturers that had already been able to carry out large volume production of MW-scale wind turbines, including Goldwind and United Power. In 2012, both of the manufacturers had the supply capacity of over 4.550 GW. Goldwind and United Power had the newly increased installed capacity of wind turbines on wind farms all over China reaching 2.5215 GW and 2.029 GW, respectively; and the quantities of wind turbines installed were 1600 and 1302 sets.

Group 2: wind turbine manufacturers that had already been able to carry out volume production of MW-scale wind turbines, including Sinove, Mingyang, XEMC, Shanghai Electric, Envision Energy, Gamesa, Dongfang Turbine, Vestas, Haizhuang Windpower, Zhuzhou Times Electric, WINDEY, SANY and CCWE. In 2012, the quantities of wind turbines installed by the foregoing manufacturers ranged from 100 to 900 sets, accounting for less than 10% market share, respectively.

Group 3: wind turbine manufacturers that had already been able to carry out small volume production of MW-scale wind turbines, including XJ Wind power, HEAG, Shenyang TEWIN, GE and INHE Wind power. By the end of 2012, the quantities of wind

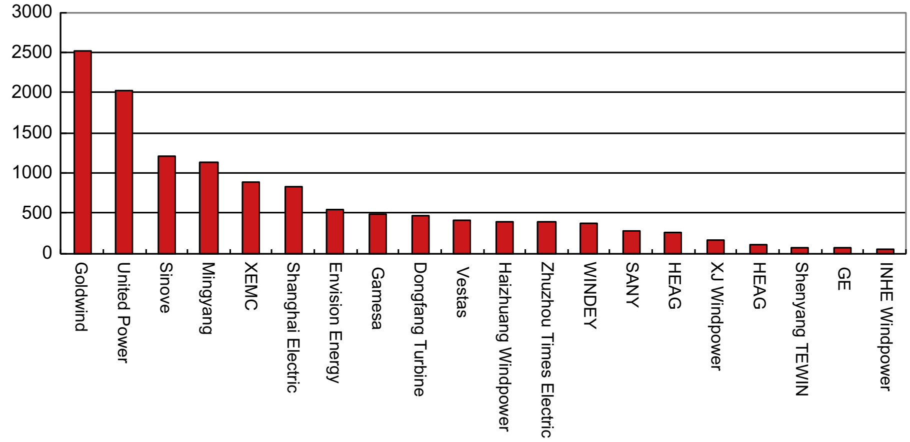


Fig. 2. Installed capacity comparisons of manufacturers in 2012.
Source: Statistics on Wind Turbine Installed Capacity in China in 2012, by Chinese Wind Energy Association under Chinese Renewable Energy Society [6].

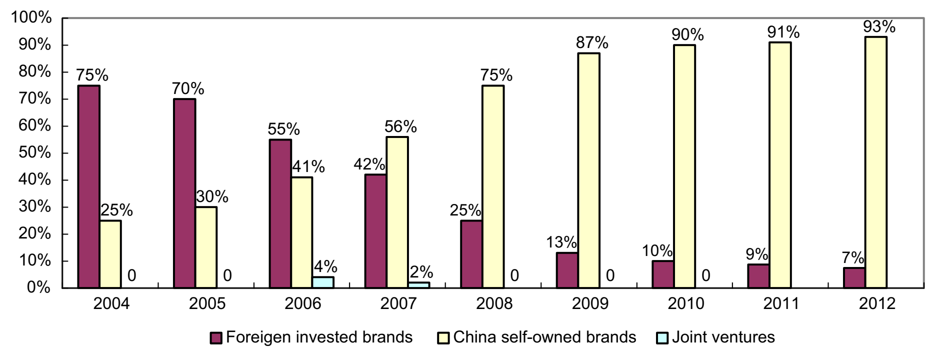


Fig. 3. Market shares of international and China's domestic wind turbine manufacturers.
Source: Preliminary statistics of the national electric power industry [9–15], Statistics on Wind Turbine Installed Capacity in China in 2012, by Chinese Wind Energy Association under Chinese Renewable Energy Society [6].

turbines installed by the foregoing manufacturers ranged from 10 to 80 sets.

Group 4: wind turbine manufacturers that had prototypes in operation and less than 10 wind turbines installed, including Beijing Jingcheng New Energy Co., Ltd., China Energine, GEOHO Energy, Xinxing Heavy Industries Group Co., Ltd., Ningxia Yinxing Energy Photovoltaic Equipment Manufacturing Co., Ltd., Dongfang Electric New Energy Equipment (Hangzhou) Co., Ltd., Tianwei Wind Power Co., Ltd. and Swiss Electric).

Group 5: other manufacturers that were engaged in design and manufacture or introduction of technologies.

Manufacturers that were able to carry out volume production of complete equipment in 2012 are compared, as shown in Fig. 2.

3. Competition in China's wind power industry

3.1. Advantages of domestic manufacturers

Before 2005, foreign manufacturers dominated China's wind turbine market with the market share exceeding 70% [7]. In 2012, the market share of foreign manufacturers dropped sharply to around 7.47%, while the market share of domestic manufacturers rose from 25% in 2004 to 92.53% in 2012 [6].

Though international manufacturers had less market share in China, some excellent international manufacturers still had significant advantage. By the end of 2012, among the top 10 complete wind turbine manufactures that had the largest market shares in China market, i.e. Goldwind, United Power, Sinove, Mingyang, XEMC, Shanghai Electric, Envision Energy, Gamesa, Dongfang Turbine and Vestas, there were two international manufacturers. According to statistics, by 2012, there had been 24 foreign manufacturers that ever had market share in China, in which most had quitted from the market and only less than 5 remained [6]. However, among the top 20 manufacturers in China's wind turbine market; there were still 3 international manufacturers, which demonstrated their strong competitiveness, as shown in Fig. 3.

To encourage development of the domestic wind turbine manufacturing industry, the National Development and Reform Commission issued a regulation in 2005 that wind farms with the wind turbine localization rate of less than 70% were not allowed to be constructed; the regulation was repealed in 2010 [8].

3.2. Localized development of foreign manufacturers

Some foreign manufacturers have registered solely-funded subsidiaries, like Vestas Denmark, Gamesa Spain, Suzlon India, Nordex German and GE Energy America, while some other manufacturers have registered joint ventures in China, like Repower German etc. All of these manufacturers have built assembly lines for complete turbines and component production

Table 4
Basic statistics on wind turbine manufacturers in China.
Source: Data sorted by Hesheng Qi from China Wind Power Equipment Association.

Serial No.	Manufacturer	Model	Main Technical parameters	Source of technology	Product progress	Location of the general assembly factory
1	Sinovel	SL1500/60/70/77/82 doubly-fed	Variable pitch and speed 1500 kW/60 m/70.4 m/77.4 m/82.9 m	Introduction of WENDTECH technical permit	With large volume production	Dalian/Yancheng/Baotou/Jiuquan/ Bayannor
		SL3000/90/100/105/110/115 doubly-fed	3000 kW/90 m/100 m/105m/110 m/115 m	WENTEC Joint design	With small volume production	
2	Dongfang Turbine	FD70/77/82 Doubly-fed	Variable pitch and speed 1500 kW/70/77/82 M	Introduction of REPOWER technical permit from Germany	With volume production	Deyang/Tianjin/branch companies are prepared to be established in Liaotong, west Mongolian region, Jiuquan, Zhangjiakou and Yancheng
		FD90/100 doubly-fed	Variable pitch and speed 2500 kW/90/100 m	Introduction of WENTEC Technology from Germany	Prototype coming off line	
		FD60 Doubly-fed	Variable pitch and speed 1000 kW/60 m	Technology from Shenyang University of Technology	In trial manufacturing	
3	Goldwind	GWS48/S50/750	Fixed pitch and speed 750(8 0 0)kW/49m/50m	Introduction of REPOWER technical permit from Germany	With large volume production	Chengde/Urumchi/
		GW70/77/82/1500	Variable pitch and speed (direct drive) 1500 kW/70 m/77 m/82 M	Introduction of VENSYS technical permit from Germany		Beijing/Urumuchi/Baotou/Dafeng/Jiuquan/Germany
		GW90, 100/2500	Variable pitch and speed (direct drive) 2500 kW/70 m/77 m/82 M	Self-independent research and development after digestion and absorption	Prototype	
		GW100/3000	Variable pitch and speed (semi-direct drive) 3000kW/70 m/77 m/82 M		Prototype	
4	Windey Wind Power	750 kW	Fixed pitch and speed 750kW/49/50m	Introduction of REPOWER technical permit from Germany	With large volume production	Deqing/North Zhangjiakou
		800 kW (deliberate speed loss)	Variable pitch and speed 800 kW/52m			
		1.5 kw Doubly-fed	Variable pitch and speed 1500 kW/70 m/77 m/82 m	Joint design with GH company from Britain	With volume production	
5	Baoding Huide Wind Power Engineering Co., Ltd.	HD1000	Fixed pitch and speed 1000 kW/55m	Introduction of Furlander technical permit from Germany	With volume production	Baoding
		HD2000 Doubly-fed	Variable pitch and speed 2050 kW/93.2 m	Introduction of WRE technology from Germany	In trial manufacturing	Planned to establish general assembly factories in Inner Mongolia/Jiangsu
6	Shanghai Electric	W1250-64-68/65 W1250-70-65 Doubly-fed	Variable pitch and speed 1250 kW/64 m/70 m	Introduction of Dewind technical permit from Germany	With large volume production	Shanghai/Dongtai
		W2000-93-80/87-80/ doubly-fed	Variable pitch and speed 2000 kW/87 m/93 m	Joint design with Aerodyn	With small volume production	
		W3600-116-90 Doubly-fed	Variable pitch and speed 3600 kW /116 m			
7	Harbin Wind Turbine Co., Ltd.	Direct drive PM	Variable pitch and speed (direct drive) 1500 kW/77 m	Self-independent research and development	Trial small volume production	Harbin
8	Beijing Beizhong Steam Turbine Generator Co., Ltd.	BZD80-2000 Doubly-fed	Variable pitch and speed 2000 kW/80 m	Introduction of DEWIND technical permit from Germany	With volume production	Beijing
9	CSR Zhuzhou Institute Co., Ltd.	WT1650/D77/D82 doubly-fed	Variable pitch and speed 1650 kW/77 m/82 m	Introduction of Windtech permit from Austria	With volume production	Zhuzhou
10	Guodian United Power Technology Co., Ltd.	UP77/82 doubly-fed	Variable pitch and speed 1500 kW/77.36 m/82.76 m	Joint design with Aerodyn	With volume production	Baoding/Chifeng/Lianyungang

Table 4 (*continued*)

Serial No.	Manufacturer	Model	Main Technical parameters	Source of technology	Product progress	Location of the general assembly factory
11	CSIC (Chongqing) Haizhuang Windpower Equipment Co., Ltd.	H56-850 excitation synchronous	Variable pitch, speed and frequency, full power 850 kW/56.3 m	Technical permit (Frisia from Germany)	With volume production	Chongqing/Shandong/Inner Mongolia
		H82/87/93-2.0MW Doubly-fed	Variable pitch and speed 2000 kW/82/87/93 m	Joint design with Aerodyn		
12	Harbin Hafei Industrial Co., Ltd.	H70-1.5/H77-1.5 MW	Variable pitch and speed (semi-direct drive) 1500 kW/70 m/77 m	Introduction of technology from Shenyang University of Technology	Operation of prototype	Harbin
13	Wuhan Guoce Nordic New Energy Co., Ltd.	GCN1000-57/59/62two impellers	Fixed pitch and speed 1000 kW/57 m/59 m/62 m	Technical permit (Delta from Sweden)	With small volume production	Wuhan
		Doubly-fed with variable pitch and speed	1.5 MW doubly-fed and constant-frequency wind turbine generator set	Introduction of technology from Shenyang University of Technology	Operation of prototype	
14	Dongfang Turbine New Energy (Hangzhou) Co., Ltd.	DF70/77/82–1500 direct drive PM	Variable pitch and speed 1500 k/70/77/82	Introduction of GH technology from Britain	Installation of prototype	Deyang/Hangzhou

facilities. More importantly, such manufacturers are using more and more components made in China in their products [5].

3.3. Brand competition

Goldwind, United Power, Sinovel and Mingyang become leading domestic wind turbine manufacturers; they are dominant in the market competition. In 2012, the foregoing four manufacturers installed, in total, 4340 wind turbines in the country, while the newly increased installed capacity in the year reached 2521.5 MW, 2029.0 MW, 1203.0 MW and 1133.5 MW, respectively. In addition, Sinovel was able to carry out volume production of 3 MW wind turbines. Manufacturers ranked after the foregoing four had increased installed capacity of no more than 1000 MW, lagging far behind the above four manufacturers. In perspective of market shares, XEMC held the largest market share, followed by Shanghai Electric, Envision Energy, Gamesa, Dongfang Turbine and Vestas. There were 13 manufacturers having the increased installed capacity of 100 to 1,000 MW; the total increased installed capacity of the 13 manufacturers was 5607 MW, accounting for 43.3% of the increased market share in China [6].

In 2012, the top 3 manufacturers accounted for 44.39% in the total increased installed capacity in China, and the top 10 manufacturers accounted for 81.17%. High concentration in the industry reflected fierce market competition.

4. Problems

4.1. Weak research and development

At the preliminary stage in development of wind turbines, there were only a few institutions engaged in research and development of wind turbines, while human resources were unstable. Though national centers have been established with support from manufacturers for engineering, technological research and development of wind turbines, they are still under great pressure imposed by insufficient policy and financial support, let alone technological progress of the industry. At present, many domestic manufacturers choose to bring in, digest and absorb foreign technologies through licenses or even engagement of foreign teams for joint research and development of wind turbines to form self-independent intellectual property. See Table 4.

Though the wind energy industry develops fast, it is not strong, because of technological restrictions and shortage of special talents. Currently, domestic wind turbine manufacturers are generally remaining at the stage of bringing in and absorbing foreign technologies, and have not their own core technologies [16]. Manufacturing of key components and the control system are still controlled by foreign manufacturers. Though the Chinese manufacturers are able to manufacture 2 MW wind turbines, they are still weak in self-independent research and development. There is still a great gap in supply of key components for MW or larger-scale wind turbines; and domestic equipments appear insufficiently reliable in quality.

4.2. Lack of professional technical personnel

The wind power industry is a comprehensive hi-tech industry integrating aerodynamics, mechanical manufacture, electricity and electronics, automatic control and highly reliable designs. For various reasons, China has not established any professional technological research and development institute for wind energy. Meanwhile, China has no talent cultivating system that can satisfy the fast development of wind power in aspects of design, manufacturing, installation, commissioning, operation and management. In general, China is still at the stage of following and introducing foreign advanced technologies for research and development of wind turbines [17].

4.3. Surplus of industrial capacity

Due to high market expectation brought by fast development of the wind power industry and ultra-low requirements for entry into the market, the wind power industry has experienced booming growth; meanwhile, through production licenses and purchase of components, the wind turbine manufacturers have realized fast production at a low threshold. From 2004 to 2008, the number of wind turbine manufacturers developed from 6 to 70 [5]. It is estimated that in the following 10 years, the average annual increase of the installed capacity will be around 8 GW. On top of the several leading manufacturers, most are only able to carry out small volume production; some are even at the stage of

researching and manufacturing prototypes or testing finished wind turbines that operate unstably. Currently there are 28 manufacturers engaged in complete equipment production, but about 13 manufacturers have the annual output of less than 100 sets.

With higher requirements for entry into the complete equipment industry, it is inevitable to reshuffle the market.

4.4. Vicious competition

So far, quality problems of wind turbines have aroused deep concern over their reliability. Surplus installed capacity in the market has led to vicious competition between manufacturers. "Price battles" have made it difficult to ensure quality of wind turbines [3]. Besides, there have been also quality problems of supporting facilities and construction technologies. For example, incompliant flanges and bolt torque caused collapse of a wind turbine in Datang Zuoyun power project; non-uniform technical standards, unavailable LVRT function of most equipments and grid failure caused wide disconnection of wind turbines from the grid [18].

4.5. Quality problem of domestic products

Quality of domestically-manufactured wind turbines has caused low utilization of the wind farms. Wind farms adopting domestically-manufactured wind turbines have obviously lower availability of wind turbines than those adopting internationally advanced wind turbines. According to rough estimation by Longyuan Power Group, the availability of wind turbines to the former is about 7% lower than to the latter [19]. In 2007 and 2008, some of the wind farm owners adopting domestically-manufactured wind turbines suffered much due to delay in delivery of the wind turbines and mismatching corollary equipments, in addition to long debugging, failure in operation test and commissioning delay of the wind turbines. In recent years, quality and technical problems have occurred during the operation of domestically-manufactured wind turbines, such as hub cracks, spindle problem, bearing problem, gearbox problem and generator faults etc. Though the quality of domestically-manufactured wind turbines has been improved on a yearly basis, their quality problems still cannot be neglected.

5. Suggestions and conclusion

Wind turbine manufacturers shall remain reasonable in the market to avoid blind investment. As an emerging industry, the wind power industry in China is at a turning point for development. Based on ensured quality, the wind power industry in China shall develop with greater importance attached to digestion and absorption of introduced technologies and self-independent innovations, so as to realize substantial breakthroughs. Only through mastering the introduced technologies and owning talents in new technologies can the wind power industry get rid of control by others and realize sustainable development.

As investments in the wind power industry feature long terms and high risks, the country should give stronger support to independent research and development of large-scale wind turbines. First, the country should include scientific researches on wind power in the national scientific and technological development plan; the country should also encourage domestic institutes to expand the innovation capacity, speed up digestion and absorption of introduced technologies and form their own independent innovation capacity. Second, the country should develop relatively strong institutes and enterprises to be relied on, and establish a national technical and development center for complete wind turbines; the country should also increase investments, and give greater supports. Third, the country should establish a technical standard and improve the inspection and certification system for wind turbines, while taking measures to ensure sound quality of wind power products and stimulating cost reduction; the country should also establish large facilities for wind power experiments, while supporting tests, inspections and certifications of new products.

The manufacturing industry is critical to development of the wind power industry in China. This paper has reviewed the current situation of the wind turbine manufacturing industry in China and analyzed the existing problems, aiming to provide references to scholars and experts.

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